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TRANSPARENT ELECTRICALLY CONDUCTIVE LAMINATE AND TOUCH PANEL

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TRANSPARENT ELECTRICALLY CONDUCTIVE LAMINATE AND TOUCH PANEL

[*Tohmei dohdensei sekisohtai to tatchi paneru*]

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[*There are no amendments to this patent.*]

[*Translator's note: Names of products and firms are spelled phonetically in this translation.*]

Specification

(54) [Title of the Invention]

Transparent electrically conductive laminate and touch panel

(57) [Claims of the invention]

[Claim 1] A transparent electrically conductive laminate produced by forming a transparent dielectric thin film with a thickness in the range of 100 to 3,000 Å on one surface of a transparent film substrate with a thickness of 2 to 120 μm and further forming a transparent electrically conductive thin film on said film and bonding a transparent substrate on the other surface with a transparent adhesive layer, which transparent electrically conductive laminate is characterized by the fact that the relation of $n_2<n_1<n_3$ can be achieved when the light refractive index of the above-mentioned film substrate is n_1, light refractive index of the above-mentioned dielectric thin film is n_2 and the light refractive index of the above-mentioned electrically conductive thin film is n_3.

[Claim 2] A touch panel where a pair of panel plates having electrically conductive thin films are arranged in such a manner that the electrically conductive thin films face one another with a spacer between them, which touch panel is characterized by the fact that at least one of panel plates is made of the transparent electrically conductive laminate described in claim 1.

[Detailed description of the invention]

[0001]

[Field of industrial application] The present invention pertains to a transparent electrically conductive laminate having a film substrate and to a touch panel made of same.

[0002]

[Prior art] In general, an electrically conductive thin film transparent in the visible light region is used as a transparent electrode for new types of display systems or touch panels such as liquid crystal displays and electroluminescence displays, as well as an antistatic measure for transparent products and for electromagnetic shielding, etc.

[0003] In the past, the so-called electrically conductive glass where an indium oxide thin film is formed on the glass is used as the aforementioned transparent electrically conductive thin film, but the substrate is made of glass; thus, flexibility and processability are poor, and it is not suitable for some applications.

[0004] Therefore, in recent years, transparent electrically conductive thin films with substrates made of various kinds of plastic films such as polyethylene terephthalate film is being promoted from the standpoint of good flexibility and processability as well as high impact strength and lightness of weight.

[0005]

[Problems to be solved by the invention] However, transparency is poor in the aforementioned conventional transparent electrically conductive thin films made with a film substrate since the light reflectivity of the surface of the thin film is high, and furthermore, scratch resistance of the electrically conductive thin film is poor, and an increase in electrical resistance and disconnects occur as a result of scratches formed during the course of use.

[0006] Furthermore, in the electrically conductive thin film used for touch panels, a pair of thin films arranged with a spacer between them come firmly into contact with each other at the pressure point from the panel plate side; thus, high resistance, that is point pressure resistance, is required, but the above-mentioned conventional transparent electrically conductive thin film lacks such a property, and life of the touch panel is reduced.

[0007] Based on the above background, the purpose of the present invention is to improve transparency and scratch resistance of electrically conductive thin films of transparent electrically conductive thin films made of a film substrate such as polyethylene terephthalate film, and to improve point pressure resistance.

[0008]

[Means to solve the problem] As a result of much research done by the present inventors in an effort to eliminate the above-mentioned existing problems, it was discovered that improvement in transparency and scratch resistance of electrically conductive thin films could be achieved when a film substrate with a specific film thickness was used and a transparent dielectric thin film having a light refractive index smaller than the light refractive index of the aforementioned substrate and a transparent electrically conductive thin film were sequentially formed on one surface of the substrate and a separate transparent substrate was applied to the other surface with a transparent adhesive layer, and an improvement in point pressure resistance could be achieved and the resulting structure could be used for touch panels, and as a result, the present invention was accomplished.

[0009] Thus, the first invention concerns a transparent electrically conductive laminate characterized by the fact that the relationship $n_2<n_1<n_3$ can be achieved when the light refractive index of the above-mentioned film substrate is n_1, light refractive index of the above-mentioned dielectric thin film is n_2 and light refractive index of the above-mentioned electrically conductive thin film is n_3 in a transparent electrically conductive laminate produced by forming a transparent dielectric thin film with a thickness in the range of 100 to 3,000 Å on one surface of a transparent substrate film with a thickness of 2 to 120 μm and further forming a transparent electrically conductive thin film on said film and bonding the transparent substrate on the other surface with a transparent adhesive layer, a ***

[0010] The second invention concerns a touch panel characterized by the fact that at least one of panel plate is made of the transparent electrically conductive laminate described in Claim 1. In a touch panel where a pair of panel plates having electrically conductive thin film is arranged in such a manner that the electrically conductive thin films face one another with a spacer between them.

[0011]

[Structure and work of the invention] For the film substrate used in the present invention, a variety of transparent plastic films having a light refractive index n_1 in the range of 1.4 to 1.7 can be mentioned. In specific terms, polyethylene terephthalate, polyimide, polyether sulfone, polyether ether ketone, polycarbonate, polypropylene, polyamide, polyacrylate, cellulose propionate, etc. can be mentioned. Among those listed above, polyethylene terephthalate with $n_1=1.66$, polyether sulfone and polyacrylate with $n_1=1.4$ to 1.5, etc. can be used effectively.

[0012] It is important for the thickness of the above-mentioned film substrate to be in the range of 2 to 120 μm, and 6 to 100 μm is further desirable. When 2 μm or below, mechanical strength of the substrate is insufficient, and fabrication of the film to form dielectric thin film and electrically conductive thin film and continuous formation of an adhesive layer are difficult. On the other hand, when the thickness exceeds 120 μm, scratch resistance of the electrically conductive thin film based on cushioning effect of the adhesive layer described below and improvement in the point pressure resistance are impossible.

[0013] A surface treatment such as etching or primer coating using the sputtering method, corona treatment, flaming treatment, ultraviolet irradiation, electron beam irradiation, chemical treatment and oxidation treatment may be provided for the above-mentioned film substrate ahead of time to increase adhesion of the dielectric thin film applied to the surface of the aforementioned substrate. Furthermore, before forming a dielectric thin film, cleaning by washing with a solvent, ultrasonic cleaning, etc. may be provided as well.

[0014] In the present invention, a transparent dielectric thin film having a light refractive index n_2 lower than the light refractive index n_1 of the aforementioned substrate (in general, approximately 1.4 to 1.7) and having a lower limit of approximately 1.3 is formed on one surface of the above-mentioned film substrate. When the above-mentioned dielectric thin film is formed, a significant improvement in transparency and scratch resistance of the electrically conductive thin film can be achieved, and furthermore, an improvement in the point pressure resistance of the touch panel is possible, as well.

[0015] For material used the aforementioned dielectric thin film, for example, inorganic materials such as NaF(1.3), Na_3AlF_6(1.35), LiF(1.36), MgF_2(1.38), CaF_2(1.4), BaF_2(1.3), SiO_2(1.46), LaF_3(1.55), CeF_3(1.63), Al_2O_3(1.63), OM-4(1.66) [the numbers inside the parenthesis for each the above-mentioned materials is the light refractive index n_2], and organic materials having light refractive index n_2 of approximately 1.4 to 1.6 such as acrylic resins, urethane resins, and siloxane type polymers can be mentioned, and materials where the light refractive index n_2 satisfies the aforementioned relationship are selected from the aforementioned materials. In particular, MgF_2, SiO_2, Al_2O3, etc. are effective.

[0016] The thickness of the dielectric thin film is in the range of 100 to 3,000 Å, and a thickness in the range of 200 to 1,000 Å is especially desirable. When the thickness is 100 Å or less, continuous film formation is less likely to be achieved, and improvement in transparency and scratch resistance is insignificant. On the other hand, when the thickness exceeds 3,000 Å, an increase in transparency cannot be expected and cracks are likely to form.

[0017] As for the dielectric thin film formation method; for example, vacuum deposition, sputtering, ion plating, coating, etc. can be mentioned, and an appropriate method can be used according to the type of the above-mentioned materials used and the film thickness required.

[0018] In the present invention, a transparent dielectric thin film is formed as described above and then, a transparent electrically conductive thin film is further formed on the aforementioned thin film. For the method used for formation of the electrically conductive thin film, the aforementioned method used for production of the dielectric thin film may be used as well. The thin film material used in this case is not limited. For example, indium oxide containing tin oxide, tin oxide containing antimony, etc. can be used.

[0019] In general, the light refractive index n_3 of the electrically conductive thin film made of the above-mentioned materials is approximately 2 and is greater than the light refractive index of the film substrate n_1. Therefore, the relationship of the light refractive index of the above-mentioned films and light refractive index of dielectric thin film becomes $n_2<n_1<n_3$.

[0020] It is desirable when the thickness of the above-mentioned electrically conductive thin film is at least 50 Å, and when the thickness is below the aforementioned thickness, formation of a continuous film having excellent conductivity having a surface resistance of 10^3 ohm/cm^2 is less likely to be produced. Furthermore, when the thickness is too high, a reduction in transparency, etc. occurs, and an appropriate thickness in the range of 100 to 3,000 Å.

[0021] For the other side of the film substrate having the aforementioned transparent dielectric thin film and transparent electrically conductive thin film formed sequentially, a transparent substrate is applied with a transparent adhesive layer. Upon bonding of the aforementioned films, an adhesive layer may be provided for the aforementioned transparent substrate and the above-mentioned film substrate may be applied to the layer, or the above-mentioned adhesive layer is provided for the film substrate and the transparent substrate may be applied to the layer. The latter method has an advantage since formation of the adhesive layer can be achieved continuously as the film substrate is formed into a roll.

[0022] For the adhesive layer used in this case, those having transparency may be used without any limitation, and for example, an acrylic type adhesive, silicone type adhesive, or rubber-type adhesive may be used. Upon bonding the above-mentioned adhesive layer to the transparent substrate, cushioning of said layer makes it possible to improve scratch resistance of the electrically conductive thin film formed on one surface of the film substrate and point pressure resistance of the touch panel. In order to enhance the above-mentioned function, it is desirable when the elastic modulus is set in the range of $1x10^5$ to $1x10^7$ dyn/cm^2, and thickness is set at least 1 μm, preferably, in the range of 5 to 100 μm.

[0023] When the above-mentioned elastic modulus is $1x10^5$ dyn/cm^2 or below, the adhesive layer becomes inelastic and easily undergoes deformation upon application of pressure and an irregular surface is likely to be formed on the film substrate as well as the electrically conductive thin film, and furthermore, oozing of adhesive is likely to occur from the cut surface, and scratch resistance of the electrically conductive thin film and increase in point pressure resistance of touch panel are reduced. On the other hand, when the elastic modulus exceeds $1x10^7$ dyn/cm^2, the adhesive layer is hardened and a cushioning effect cannot be expected, and improvement in scratch resistance of the electrically conductive thin film and increase in point pressure resistance of the touch panel cannot be expected.

[0024] Furthermore, when the thickness of the adhesive layer is 1 μm or less, a cushioning effect cannot be expected; thus, an increase in scratch resistance of the electrically conductive thin film and an increase in point pressure resistance of the touch panel cannot be expected. On the other hand, when the thickness is high, loss of transparency occurs and formation of an adhesive layer and bonding of the transparent substrate require a higher cost.

[0025] The transparent substrate bonded with an adhesive layer provides high mechanical strength to the film substrate and prevent curling, and when flexibility is required, a plastic film having a thickness of 6 to 300 μm is commonly used, and when flexibility is not required, a glass sheet or plastic sheet with a thickness of 0.05 to 10 mm is commonly used. For the plastic material, those listed for the aforementioned film substrate can be used in this case as well.

[0026] Furthermore, in order to increase visibility, anti-glare layer or anti-reflective layer may be formed on the outer surface (opposite side from the adhesive layer) of the aforementioned transparent substrate or for protection of the outer surface, a hard coat layer may be formed. For the hard coat layer, a hard film of melanin resin, urethane resin, alkyd resin, acrylic resin, silicon resin, etc. can be used effectively.

[0027] Fig. 1 shows an example of the transparent electrically conductive laminate of the present invention. Transparent dielectric thin film 2 is formed on one surface of transparent film substrate 1 and transparent electrically conductive thin film 3 is further formed on the aforementioned film. And transparent substrate 5 is bonded to the other surface with a transparent adhesive layer 4. Furthermore, Fig. 2 shows a different example of the transparent electrically conductive laminate of the present invention. In this case, hard coat layer 6 is formed on the outer surface of the aforementioned transparent substrate 5, and the rest of the structure is the same as Fig. 1.

[0028] Fig. 3 shows an example of a touch panel that utilizes the transparent electrically conductive laminate of the present invention. In a touch panel where a pair of panel plates P1 and P2 having electrically conductive thin film P_1d and P_2d are arranged with spacer S in such a manner that P_1d and P_2d face each other, the above-mentioned transparent electrically conductive laminate, the structure shown in Fig. 2 is used as one of panel plates P_1.

[0029] The aforementioned touch panel functions as a transparent switch structure where pressure is applied with finger tip M from the panel plate P_1 side, electrically conductive thin films P_1d and P_2d come in contact with one another and form the ON state of electrical circuit and when the above-mentioned pressure is released, the initial OFF state is restored. In this case, the panel plate P_1 is made of the above-mentioned transparent electrically conductive laminate; thus, excellent scratch resistance of the electrically conductive thin film and point pressure resistance can be achieved, and the above-mentioned function can be stably maintained for a long time.

[0030] Furthermore, in Fig. 3, panel plate P_1 may be the transparent electrically conductive laminate shown in Fig. 1 as well. In this case, panel plate P_2 is a plastic film or glass sheet and is provided with a electrically conductive thin film P_2d, and the aforementioned transparent electrically conductive laminate shown in Fig. 1 and Fig. 2 may be used as well.

[0031]

[Effect of the invention] As described above, according to the present invention, production of a transparent electrically conductive laminate with improved scratch resistance of the electrically conductive thin film based on hardness of the dielectric thin film and cushioning effect of the adhesive layer is made possible and improved point pressure resistance of the touch panel is made possible, and an improved transparency based on the combination of dielectric thin film and electrically conductive thin film can be achieved, and furthermore, production of a touch panel made of the aforementioned laminate is made possible.

[0032]

[Working Examples] The present invention is explained in further detail with the working examples below. In this case, parts indicates parts by weight.

[0033] Working Example 1

Vacuum deposition of SiO_2 was provided for one surface of the substrate film (light refractive index n_1=1.66), which is a polyethylene terephthalate film (hereinafter referred to as PET film) with a thickness of 25 μm, using the electron beam heating method and a degree of vacuum of

$(1\text{-}2)\times10^{-4}$ Torr to form a transparent dielectric thin film (hereinafter referred to as SiO_2 thin film) SiO_2 with a thickness of approximately 400 Å (light refractive index $n_2=1.46$).

[0034] Furthermore, a transparent electrically conductive thin film made of a composite oxide (light refractive index $n_3=2.00$) of indium oxide and tin oxide with a thickness of 300 Å was formed on the above-mentioned SiO_2 thin film in an atmosphere of 80% argon gas and 20% oxygen gas under 4×10^{-3} Torr (hereinafter referred to as ITO thin film).

[0035] And furthermore, an acrylic type transparent adhesive layer (1 part of isocyanate type crosslinking agent was mixed with 100 parts of an acrylic type copolymer of butyl acrylate, acrylic acid, and vinyl acetate with a weight ratio of 100:2:5) in which the elastic modulus has been adjusted to 1×10^6 dyn/cm^2 was formed on the other surface of the above-mentioned PET film to a thickness of approximately 20 μm, and then, a transparent substrate, consisting of a PET film with a thickness of 125 μm, was applied to form a transparent electrically conductive laminate film having the structure shown in Fig. 1.

[0036] The aforementioned transparent electrically conductive laminate film was used as one panel plate and a glass sheet with an ITO thin film deposited on it to a thickness of 300 Å was used as the other panel plate, and the above-mentioned two panel plates were arranged with a spacer having a thickness of 100 μm in such a manner that ITO thin films face one another and a touch panel used as a switch structure was produced. In this case, the ITO thin film on each panel plate was produced so as to form stripes that mutually cross.

[0037] Working Example 2

One surface of a PET film was coated to a thickness of 125 μm with a toluene solution produced by adding 5 parts of hydroxycyclohexylphenylketone [product of Ciba Geigy Co., trade name Irgacure 184] to 100 parts of an acrylic-urethane type resin [product of Dainippon Ink and Chemical Co., trade name: Unidic 17-806] and diluted to 50 wt% and drying was provided for 3 minutes at 100°C, and ultraviolet radiation was applied with two ozone type high-pressure mercury lamps (80 W/cm, 15 cm condenser) and a hard coat layer with a thickness of 5 μm was formed.

[0038] A PET film provided with the aforementioned hard coat layer was used as the transparent substrate and the side opposite from the aforementioned hard coat layer was bonded with an adhesive layer and a transparent electrically conductive laminate film having the structure shown in Fig. 2 was produced. Furthermore, using the aforementioned film laminate, a touch panel having the structure shown in Fig. 3 was produced as in the case of Working Example 1.

[0039] Working Examples 3 and 4

The thickness of the SiO_2 thin film was changed to 200 Å (Working Example 3) and 1,600 Å (Working Example 4) and two different transparent electrically conductive laminate films having the structure shown in Fig. 2 were produced. Furthermore, using the aforementioned laminated films, two different touch panels having the structure shown in Fig. 3 were produced as in Working Example 1.

[0040] Working Example 5

Instead of the SiO_2 thin film, a transparent dielectric thin film made of MgF_2 (light refractive index n_2=1.38) with a thickness of approximately 400 Å produced by vacuum depositing MgF_2 at a vacuum of $(1\text{-}2)\times10^{-4}$ Torr by the electron beam heating method and a transparent electrically conductive laminate film having the structure shown in Fig. 2 was produced as in Working Example 2. Furthermore, using the aforementioned film laminate, a touch panel having the structure shown in Fig. 3 was produced as in Working Example 1.

[0041] Comparative Example 1

Formation of the SiO_2 thin film and adhesive layer and bonding of the transparent substrate were omitted and a transparent electrically conductive laminate film was produced as in Working Example 1, and a touch panel was produced with the aforementioned film as in Working Example 1.

[0042] Comparative Example 2

Formation of SiO_2 thin film was omitted and a transparent electrically conductive film laminate was produced as in Working Example 1 and a touch panel was produced with the aforementioned film as in Working Example 1.

[0043] Comparative Example 3

Formation of an adhesive layer and bonding with a transparent substrate were omitted, and a transparent electrically conductive laminate film was produced as in Working Example 1 and a touch panel was produced with the aforementioned film as in Working Example 1.

[0044] Comparative Example 4

As a film substrate, a PET film having a thickness of 125 μm was used and a transparent electrically conductive film laminate was produced as in Working Example 1 and a touch panel was produced with the aforementioned film as in Working Example 1.

[0045] For each of the transparent electrically conductive film laminates produced in Working Examples 1 to 5 and Comparative Examples 1 to 4 above, the film resistance, light transmittance, and scratch resistance of the conductive thin film were measured according to the methods described below. Furthermore, the point pressure resistance was measured for each touch panel produced in Working Examples 1 to 5 and Comparative Examples 1 to 4 above, as well. The results obtained are shown in Table I below.

[0046] <Film resistance> The surface electrical resistance (ohm/square) of the film was measured using the two pole method.

[0047] <Light transmittance> The visible light transmittance was measured at a wavelength of 550 nm using a spectroanalyzer, UV-240, product of Shimazu Co., Ltd.

[0048] <Scratch resistance of the electrically conductive thin film> Using a Heidon surface tester, TYPE-HEIDON 14, of Shinto Kagaku Co., scratching of the surface of the electrically conductive thin film was done under the following conditions: (1) scratches: gauze (type I of Japan Pharmaceuticals), (2) weight: 100 g/cm^2, (3) scratch rate: 30 cm/min, (4) number of repetitions: 100 times (50 reciprocating motions), and the film resistance (Rs) to scratching and change (Rs/Ro) with respect to the initial film resistance (Ro) was measured and the scratch resistance was evaluated.

[0049] <point pressure resistance> Center //point pressure// was applied 1,000,000 times with a rod (hook end 7R) made of urethane rubber with a hardness of 40 to the panel plate structure of the transparent electrically conductive laminate film under a load of 100 g, and the film resistance (Rd) was measured and an evaluation was made of the change with respect to the initial film resistance (Ro) (Rd/Ro). In this case, the measurement of the aforementioned film resistance was done for contact resistance of electrically conductive thin films arranged facing one another at the time of application of point pressure and the result is shown as the mean value.

[0050]

[Table I]

Table I

	Film resistance (ohm/square)	Light transmittance (%)	Scratch resistance (Rs/Ro)	Point pressure resistance (Rd/Ro)
Work. Ex. 1	300	87	1.5	1.0
" 2	300	88	1.5	1.0
" 3	300	85	2.0	1.0
" 4	300	85	1.0	1.0
" 5	300	88	1.5	1.0
Comp. Ex. 1	300	84	130	20 or higher
" 2	300	84	60	1.0
" 3	300	87	3.0	15
" 4	300	87	3.0	10

[0051] As shown in the results in Table I, the transparent electrically conductive laminate films of the present invention exhibit high conductivity, high transparency, and high scratch resistance, and furthermore, when the transparent electrically conductive laminate film of the present invention is used, production of a touch panel with superior point pressure resistance is made possible.

[Brief description of figures]

[Fig. 1] A cross-section view of an example of a transparent electrically conductive laminate of the present invention.

[Fig. 2] A cross-section view of a different example of a transparent electrically conductive laminate of the present invention.

[Fig. 3] A cross-section view of an example of a touch panel of the present invention.

[Explanation of codes]

1: Transparent film substrate

2: Transparent dielectric thin film

3: Transparent electrically conductive thin film

4: Transparent adhesive layer

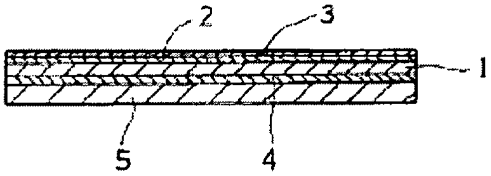
5: Transparent substrate

P_1, P_2: pair of panel plates

P_1d, P_2d: electrically conductive thin film

S: Spacer

[Fig. 1]



1: Transparent film substrate

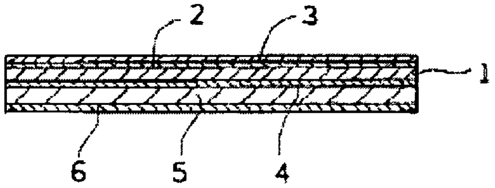
2: Transparent dielectric thin film

3: Transparent electrically conductive thin film

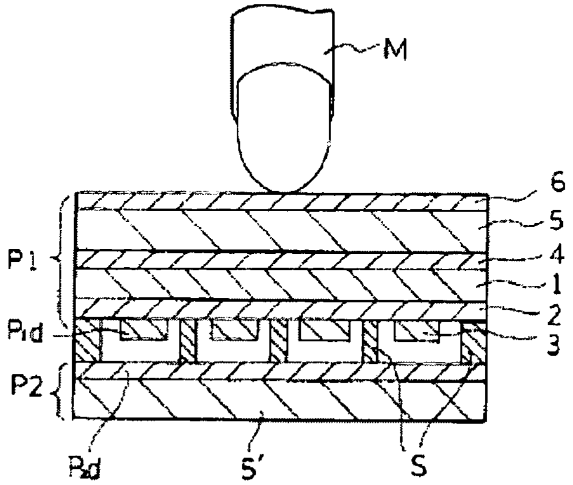
4: Transparent adhesive layer

5: Transparent substrate

[Fig. 2]



[Fig. 3]



P_1, P_2: pair of panel plates

P_1d, P_2d: electrically conductive thin film

S: Spacer

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